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19 May 95

MEMORANDUM FOR WR-ALC/EMR
ATTN: Lt Col Branton
216 Ocmulgee Court
Robins AFB, GA 31098-0983

FROM: HQ AFCEE/ERT
8001 Arnold Drive
Brooks AFB, TX 78235-5357

SUBJECT: Completion of One-Year Bioventing Test, Robins AFB Site 272, Site UST 173, and Site SS-10

The Air Force Center for Environmental Excellence (AFCEE) one-year bioventing test and evaluation projects at Robins AFB have been completed. A site map (Figure 1) and two tables (Table 1 and Table 2) are attached for two of the three sites listed above. Figure 1 provides general site information; Table 1 provides a summary of initial, six-month, and one-year fuel respiration and degradation rates measured at various monitoring points at both sites; and Table 2 provides a summary of initial and final soil and soil gas analytical results for total petroleum hydrocarbons (TPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX) at both sites. A bioventing system was not installed at Site 272 due to low TPH concentrations at initial sampling points. Based on the results from your sites and numerous other sites throughout the Air Force, bioventing is cost-effectively remediating fuel contamination in a reasonable time frame. We recommend that other sites at your facility be evaluated for possible use of this technology. The sites should be evaluated using the criteria in the AFCEE Test Plan and Technical Protocol for a Field Treatability Test for Bioventing, May 1992, including Addendum One, February 1994. These are found in the "Tool Box" recently sent to your base.

The objective of the one-year sampling and evaluation effort was not to collect enough samples for a statistical evaluation, but rather to demonstrate the feasibility of using bioventing to reduce TPH and BTEX concentrations in fuel-contaminated soil and soil gas. The results of soil and soil gas sample analyses and respiration testing were used to evaluate the performance of this technology for each site.

Soil gas samples are similar to composite soil samples in that they are collected over a larger vertical interval than a discrete sample collected at a specific depth. Thus, they provide an indication of changes in soil gas profiles and volatile contaminant concentrations (see Addendum One to the AFCEE Test Plan and Technical Protocol for a Field Treatability Test for Bioventing-Using Soil Gas Surveys to Determine Bioventing

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Feasibility and Natural Attenuation Potential, February 1994). Soil samples, on the other hand, are discrete point samples subject to large variability over small distances and/or soil types. Because of the wide variations inherent in the soil sample collection and analysis process, the analytical results from soil samples alone should not be viewed as conclusive indicators of bioventing progress or evidence of the success or failure of this technology. For example, the initial and one-year samples for soil hydrocarbons at Site SS-10 were collected at different depths. This point is well illustrated at the Robins sites in that the TPH and BTEX concentrations in the soil gas samples decreased while the concentrations in many of the soil samples increased during the period of the study. For this reason, in situ respiration tests and associated soil gas sampling and analysis are considered better indicators of hydrocarbon remediation than limited soil sampling.

The following paragraphs provide site-specific information on the analytical results from samples collected at the bioventing sites at Robins AFB.

Site 272

Initial oxygen concentrations ranged from 5.0 to 21.0 percent, with the majority of the oxygen concentrations above 16 percent. The TPH concentrations at all sampling points were low, with the highest measurements being 200 ppm. These results indicate that there was little contamination at this site, and it was unlikely that a bioventing system would be practical. For these reasons, a bioventing system was not installed at this site.

Site UST-173

Degradation rates at the locations for which multiple sets of data were available showed substantial decreases between the initial and six-month sampling events and the six-month and one-year sampling events, indicating a decrease in the amount of fuel available for degradation (Table 1).

A comparison of the initial and final soil gas analytical results for all points showed a large decrease in the concentrations of TPH and BTEX at the vent well as well as locations MPA-21.8 and MPC-15.0 (Table 2). These measurements indicate that fuel biodegradation progressed at a significant pace. Initial concentrations of TPH and BTEX in the soils were very low, except for the TPH of 5,700 mg/kg at sample location MPA-8.5. It is anticipated that the final soil samples for this site will be collected in May 1995.

Site SS-10

Degradation rates at the three locations for which initial and six-month data were available decreased between the two sampling events. Degradation rates at the six locations for which data were available for the six-month and one-year sampling events also decreased. These decreases in degradation rates generally indicated a significant

decrease in the amount of fuel available for degradation. The degradation rates at sample locations MPB-4.5 and MPB-6.0 anomalously increased between the six-month and one-year sampling events. The MPC-3.0, MPC-4.5, and MPC-6.0 locations were not oxygenated, and therefore, no comparisons can be made (Table 1).

A comparison of the initial and final soil gas analytical results for all points showed a substantial decrease in the concentrations of TPH and BTEX at the vent well as well as at locations MPA-5.0 and MPC-8.0 (Table 2). These measurements indicate that fuel biodegradation progressed at a significant pace. TPH and BTEX concentrations in the soil samples increased between collection of the initial and final samples. Unfortunately, none of the one-year soil samples were collected either from the same or near the same location or depths as were the initial samples. For this reason, a direct comparison and evaluation of the decrease in TPH or BTEX concentrations could not be made with this data. For example, one of the initial soil samples was collected at location MPA-5.0 and the correlative one-year sample was collected at location MPB-7.0.

Based on the results of this evaluation, AFCEE recommends that the bioventing pilot system at each site continue to operate while planning for additional work at each site. Based on an evaluation of the current conditions, an expansion of the systems for full-scale remediation may be recommended for Site SS-10. Recommendations for Site UST-173 will be made once the final soil samples have been collected and analyzed and the data has been evaluated. System expansion to a full-scale bioventing system can be contracted through AFCEE. Please contact Lt. MaryAnn Jenner, AFCEE/ERT, DSN 240-4364, COM 210-536-4364, to discuss technical and contractual options for full-scale expansion.

Data from your base and many others indicate that BTEX compounds are preferentially biodegraded over TPH. Since BTEX compounds represent the most toxic and mobile fuel constituents, a BTEX standard is a risk-based standard. We strongly encourage its use over an arbitrary TPH standard. Within the AFCEE Risk-based Petroleum Hydrocarbon "Tool Box," the report "Using Risk-based Standards Will Shorten Cleanup Time at Petroleum-Contaminated Sites" summarizes the BTEX/TPH issue and will assist you in negotiating for a BTEX cleanup standard.

In general, quantitative destruction of BTEX can be accomplished through bioventing. The time frame for this destruction to occur is based on a variety of factors, such as initial contaminant concentrations, site lithology, and depth to groundwater. Soil gas surveys and respiration tests can be used as BTEX destruction indicators. If a non-risk-based/TPH cleanup is chosen, the pilot and full-scale systems should be operated until respiration rates approach background rates. We recommend that confirmatory soil sampling be conducted four to six months after background respiration rates are approached.

Due to the streamlined nature of this evaluation project, the interim results report and this letter will be the only project documentation provided to the base. The interim

results report contains site diagrams and analytical results from initial soil and soil gas samples. Attachments to this letter provide the analytical results for the final soil and soil gas samples and this letter provides a summary of the collected data and recommendations for follow-on activities. AFCEE is no longer responsible for the operation, maintenance, or monitoring of the bioventing sites. We have initiated a contract to extend monitoring at some sites beyond the initial one-year test. Monitoring will include soil gas and respiration tests to document hydrocarbon degradation, but also may include the collection of sufficient final soil samples to statistically demonstrate site cleanup. If you are interested, please call us.

The blowers and accessories are now base property and should continue to be used on this or other bioventing sites. Although the current equipment is explosion-proof, under no circumstances should it be used for soil vapor extraction unless appropriate explosion-proof wiring is provided. If the base does not want to keep the blowers, or if you have further questions, please contact us.

On behalf of the AFCEE/ERT staff, I would like to thank you for your support of these bioventing test and evaluation projects. The information gained from each site will be invaluable in evaluating this technology and will promote its successful application on other Department of Defense (DOD), government, and private sites. I have attached a customer satisfaction survey. Please take a few minutes to fill it out and tell us how we did. We look forward to hearing from you.

ROSS N. MILLER, Lt Col, USAF, BSC
Chief, Technology Transfer Division

Attachments:
1. Figure 1(2 each)Site Maps
2. Table 1(2 each)Respiration and Degradation Rate Tables
3. Table 2(2 each)Initial and One-Year Soil and Soil Gas Analytical Results Tables
4. Survey

cc: AFCEE/ERD (Mr. Dave McMindes)
AL/EQW (Ms. Cathy Vogel)
HQ AFMC/CEVR
HQ USAF/CEVR
Battelle (Mr. Rob Hinchee)

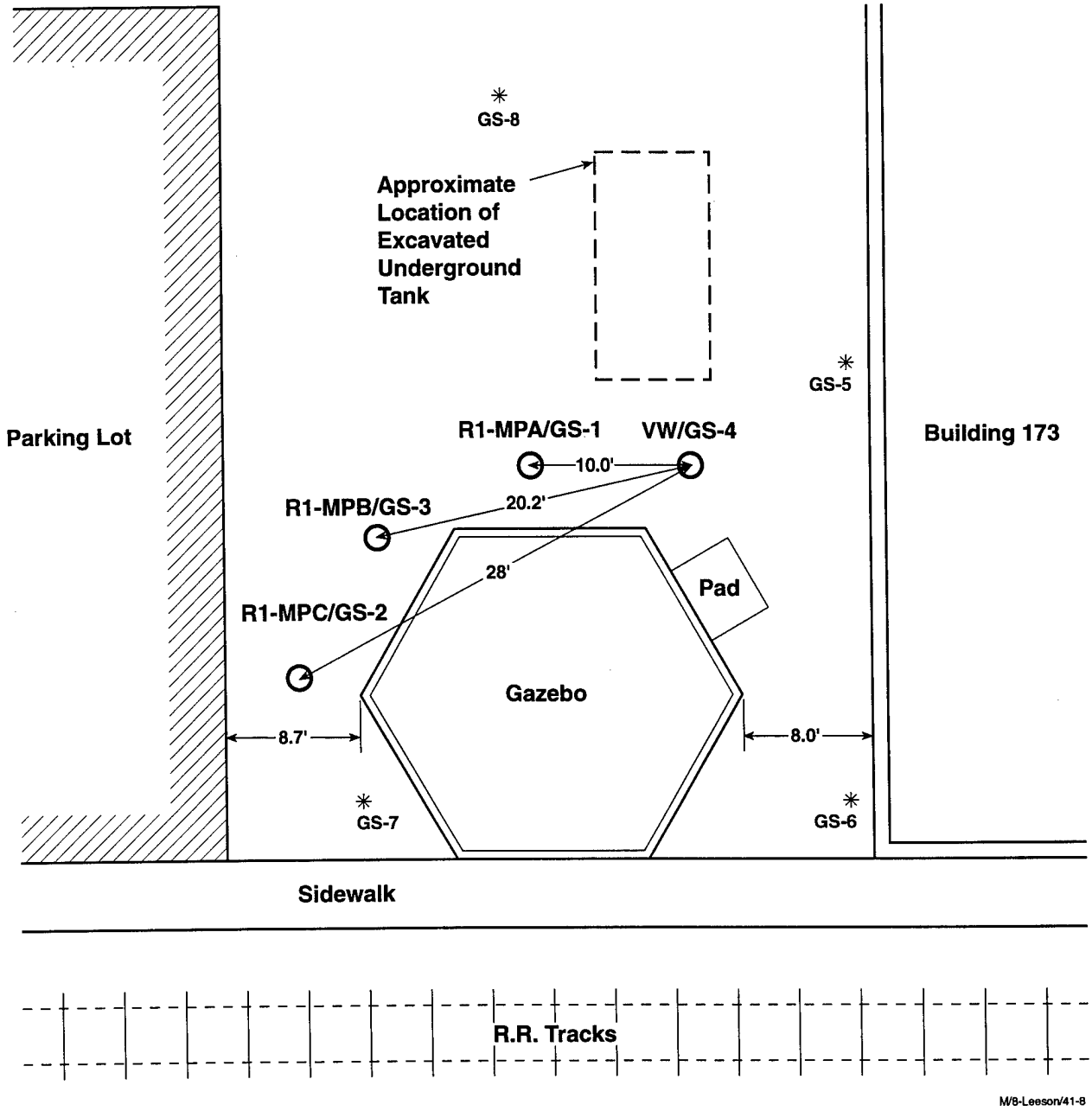

Figure 1. Schematic Diagram of Site UST 173, Robins AFB, GA Showing Locations of the Vent Well, Monitoring Points, and Soil Gas Survey Points

Table 1. Respiration and Degradation Rates at Site UST 173, Robins AFB, GA

Location	Initial: September 1, 1992			6-Month: January 19, 1993			1-Year: October 19, 1993		
	K_O (% O_2/day)	K_D (mg/kg/yr)	Soil Temperature (°C)	K_O (% O_2/day)	K_D (mg/kg/yr)	Soil Temperature (°C)	K_O (% O_2/day)	K_D (mg/kg/yr)	Soil Temperature (°C)
MPA-6.8				No flow		20.8	2.1	610	
MPA-14.5	0.94	270		0.11	32				
MPA-21.8	0.67	200	25.4	0.014	4.1	17.6			
MPB-8.0				0.046	13		0[1]	0[1]	
MPB-15.0				0.056	16		0[1]	0[1]	
MPB-23.0				0.043	13		0[1]	0[1]	
MPC-8.0				0.043	13		0[1]	0[1]	
MPC-15.0	0.70	200		0.087	25		0[1]	0[1]	
MPC-23.0	0.48	140		0.043	13		0[1]	0[1]	

[1] No respiration observed at this monitoring point.

Table 2. Initial and 1-Year Soil and Soil Gas Analytical Results at Site UST 173, Robins AFB, GA

Analyte (units)	Sample Location					
Soil Gas Hydrocarbons	VW		MPA-21.8		MPC-15.0	
	Initial August 30, 1992	1-Year May 20, 1994	Initial August 30, 1992	1-Year May 20, 1994	Initial August 30, 1992	1-Year May 20, 1994
TPH (ppm)	300	0.27	290	1.7	27	1.4
Benzene (ppm)	ND	ND	ND	0.067	ND	0.19
Toluene (ppm)	0.025	ND	0.052	0.020	0.0060	0.012
Ethylbenzene (ppm)	0.31	ND	0.055	ND	0.14	ND
Xylenes (ppm)	2.2	ND	0.81	0.039	0.098	0.010
Soil Hydrocarbons	VW-4.0		VW-18.5		MPA-8.5	
	Initial August 27, 1992	1-Year	Initial August 27, 1992	1-Year	Initial August 27, 1992	1-Year
TPH (mg/kg)	37		8.0		5,700	
Benzene (mg/kg)	ND		ND		ND	
Toluene (mg/kg)	ND		ND		0.0020	
Ethylbenzene (mg/kg)	0.33		ND		0.0090	
Xylenes (mg/kg)	3.0		0.0037		0.079	
Moisture (%)	16.2		9.1		17.5	

ND Not detected.

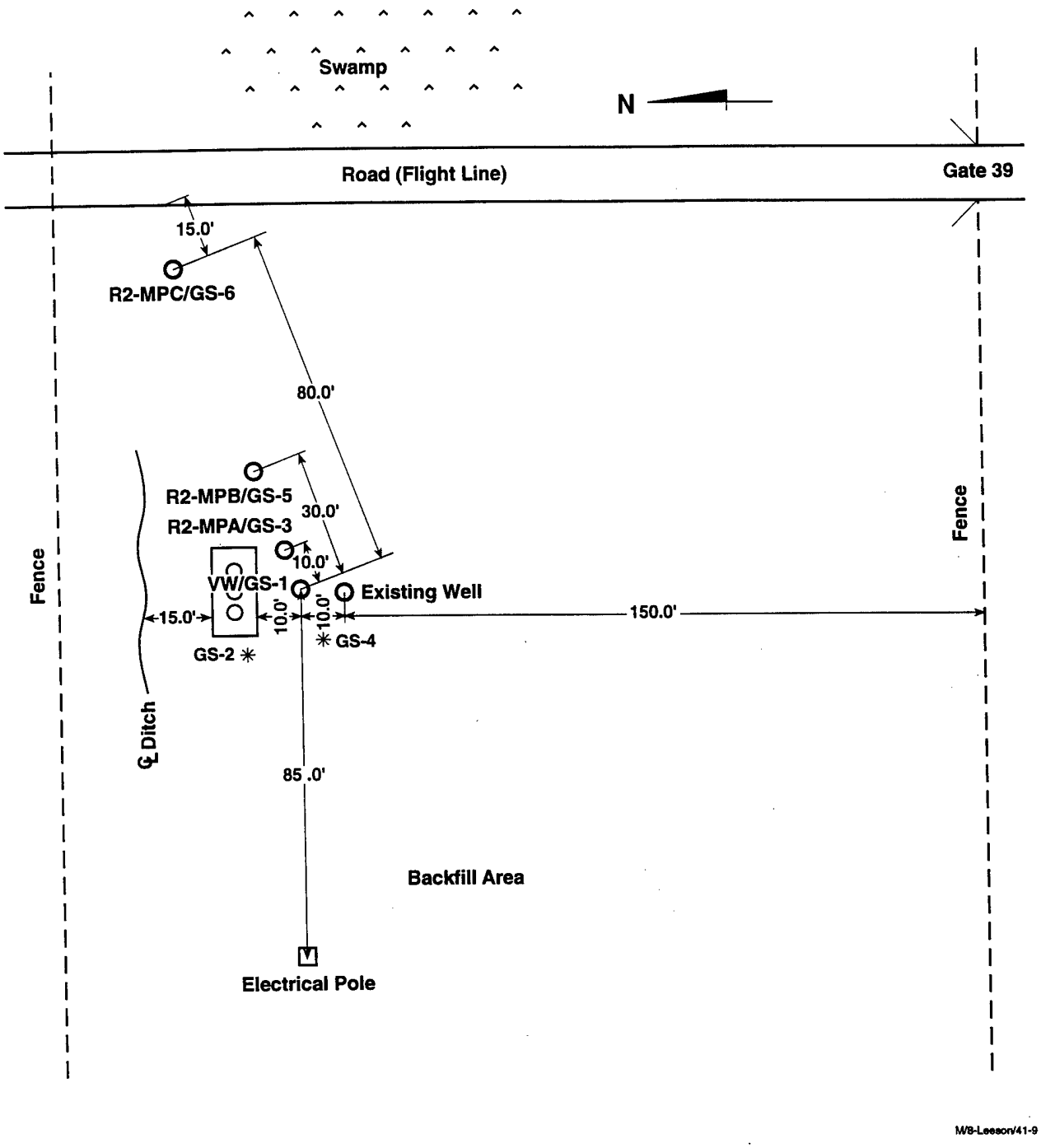

Figure 1. Schematic Diagram of Site SS-10, Robins AFB, GA Showing Locations of the Vent Well, Monitoring Points, and Soil Gas Survey Points

Table 1. Respiration and Degradation Rates at SS-10, Robins AFB, GA

Location	Initial: September 5, 1992			6-Month: January 19, 1993			1-Year: October 19, 1993		
	K_O (% O_2/day)	K_B (mg/kg/yr)	Soil Temperature (°C)	K_O (% O_2/day)	K_B (mg/kg/yr)	Soil Temperature (°C)	K_O (% O_2/day)	K_B (mg/kg/yr)	Soil Temperature (°C)
MPA-3.0			28.4	1.7	500	12.9	0.029	8.5	
MPA-4.5	1.5	440		0[1]	0[1]		0[1]	0[1]	
MPA-6.5	1.8	530	28.1	0[1]	0[1]	15.1	0[1]	0[1]	
MPB-3.0				0.58	170		0.32	93	
MPB-4.5				0.19	55		0.99	290	
MPB-6.0				0.16	47		1.6	470	
MPC-3.0				1.4	410		Not oxygenated		
MPC-4.5	8.2	2,400		1.9	560		Not oxygenated		
MPC-6.0	6.2	1,800		No flow			Not oxygenated		

[1] No respiration observed at this monitoring point.

Table 2. Initial and 1-Year Soil and Soil Gas Analytical Results at SS-10, Robins AFB, GA

Analyte (units)	Sample Location					
Soil Gas Hydrocarbons	VW		MPA-5.0		MPC-8.0	
	Initial September 3, 1992	1-Year May 20, 1994	Initial September 3, 1992	1-Year May 20, 1994	Initial September 3, 1992	1-Year May 20, 1994
TPH (ppm)	42,000	6.7	50,000	77	72,000	40,000
Benzene (ppm)	260	0.020	220	0.13	330	170
Toluene (ppm)	120	0.026	87	0.30	120	120
Ethylbenzene (ppm)	11	0.029	14	0.16	22	44
Xylenes (ppm)	81	0.16	72	0.86	100	200
Soil Hydrocarbons	MPA-3.0	MPA-7.0	MPA-5.0	MPB-7.0	VW-7.25	MPC-7.0
	Initial September 1, 1992	1-Year October 19, 1993	Initial September 1, 1992	1-Year October 19, 1993	Initial September 1, 1992	1-Year October 19, 1993
TPH (mg/kg)	150	2,430	58	1,940	9,000	6,310
Benzene (mg/kg)	0.053	22	ND	ND	ND	ND
Toluene (mg/kg)	0.098	60	0.70	3.0	59	ND
Ethylbenzene (mg/kg)	0.054	58	2.0	5.5	39	ND
Xylenes (mg/kg)	0.54	270	6.8	41	220	1.1
Moisture (%)	11.8	14.0	9.8	12.0	8.2	10.0

ND Not detected.